

WHAT IS CLAIMED IS:

1 1. A method of manufacturing an ink jet recording head which includes a
2 plurality of nozzle orifices forming at least one nozzle row, pressure chambers
3 each communicated with the associated nozzle orifice, pressure generating
4 elements each generating pressure fluctuation in ink provided in the
5 associated pressure chamber to eject an ink droplet from the associated
6 nozzle orifice, the method comprising the steps of:

7 assembling the ink jet recording head;

8 measuring a natural period of the ink pressure fluctuation in the
9 pressure chamber of the assembled recording head; and

10 classifying the assembled recording head into a plurality of ranks,
11 based on the measured natural period.

1 2. The manufacturing method as set forth in claim 1, wherein the
2 measuring step includes the steps of:

3 supplying an evaluation signal including at least an excitation element
4 which excites the ink pressure fluctuation, and an ejection element which
5 follows the excitation element to eject the ink droplet from the nozzle orifice;

6 measuring an ejected amount of the ink droplet at plural times while
7 varying a time period between a termination end of the excitation element and
8 an initial end of the ejection element; and

9 identifying the natural period based on a correlation between the time
10 period and the measured ink amount.

1 3. The manufacturing method as set forth in claim 2, wherein the time
2 interval includes at least:

3 a first time period which is determined such that the ejected ink amount
4 becomes minimum when the natural period is as per a designed criterion;
5 a second time period which is shorter than the first time period; and
6 a third time period which is longer than the first time period.

1 4. The manufacturing method as set forth in claim 1, wherein the
2 measuring step includes the steps of:

3 supplying an evaluation signal including at least an excitation element
4 which excites the ink pressure fluctuation, and an ejection element which
5 follows the excitation element to eject the ink droplet from the nozzle orifice;
6 measuring an ejected speed of the ink droplet at plural times while
7 varying a time period between a termination end of the excitation element and
8 an initial end of the ejection element; and
9 identifying the natural period based on a correlation between the time
10 period and the measured ejection speed.

1 5. The manufacturing method as set forth in claim 4, wherein the time
2 interval includes at least:

3 a first time period which is determined such that the ejection speed
4 becomes minimum when the natural period is as per a designed criterion;
5 a second time period which is shorter than the first time period; and
6 a third time period which is longer than the first time period.

1 6. The manufacturing method as set forth in claim 2 or 4, wherein duration
2 of the excitation element is equal to the natural period as per the designed
3 criterion or less.

1 7. The manufacturing method as set forth in claim 6, wherein the duration
2 of the excitation element is equal to one half of the natural period as per the
3 designed criterion or less.

1 8. The manufacturing method as set forth in claim 1, wherein the plurality
2 of ranks includes at least a first rank which indicates the measured natural
3 period is as per a designed criterion, a second rank which indicates the
4 measured natural period is shorter than the designed criterion, and a third rank
5 which indicates the measured natural period is longer than the designed
6 criterion.

1 9.. The manufacturing method as set forth in claim 1, further comprising
2 the step of indicating the classified rank on the assembled recording head.

1 10. The manufacturing method as set forth in claim 9, wherein the
2 classified rank is indicated by a symbol.

1 11. The manufacturing method as set forth in claim 9, wherein the rank is
2 determined with regard to the respective nozzle rows; and
3 wherein the rank is indicated by a symbol which indicates a
4 combination of the classified ranks of the respective nozzle rows.

1 12. The manufacturing method as set forth in claim 9, wherein the
2 classified rank is indicated by coded information which is readable by an
3 optical reader.

1 13. The manufacturing method as set forth in claim 1, further comprising
2 the steps of:

3 providing a memory; and
4 storing electrically information indicating the classified rank in the
5 memory.

1 14. A method of driving the ink jet recording head manufactured by the
2 method as set forth in claim 1, comprising the steps of:

3 providing a drive signal including at least one wave element having a
4 control factor which is defined in accordance with the classified rank; and
5 supplying the drive signal to the pressure generating element.

1 15. The driving method as set forth in claim 14, wherein the drive signal is
2 provided with an ejection element which ejects an ink droplet from the nozzle
3 orifice and a damping element which follows the ejection element to damp
4 vibration of a meniscus of the ink in the nozzle orifice; and
5 wherein a control factor of the damping element is defined in the drive
6 signal provision step.

1 16. The driving method as set forth in claim 14, wherein the drive signal is
2 provided with a characteristics changing element which changes ejection
3 characteristics of the ink droplet; and

4 wherein a control factor of the characteristics changing element is
5 defined in the drive signal provision step.

1 17. An ink jet recording apparatus, comprising:

2 an ink jet recording head, manufactured by the method as set forth in
3 claim 1; and

4 a waveform controller, which provides a drive signal including at least
5 one wave element having a control factor which is defined in accordance with
6 the classified rank.

1 18. The recording apparatus as set forth in claim 17, wherein the drive
2 signal is provided with an ejection element which ejects an ink droplet from the
3 nozzle orifice and a damping element which follows the ejection element to
4 damp vibration of a meniscus of the ink in the nozzle orifice; and

5 wherein the waveform controller defines a control factor of the damping
6 element.

1 19. The recording apparatus as set forth in claim 17, wherein the drive
2 signal is provided with a first drive pulse including:

3 a first expansion element, which expands the pressure chamber such
4 an extent that an ink droplet is not ejected from the nozzle orifice;

5 a first ejection element, which follows the first expansion element to

6 contract the pressure chamber to eject an ink droplet from the nozzle orifice;
7 a holding element, which follows the first ejection element to hold the
8 contracted state of the pressure chamber for a predetermined duration; and
9 a first damping element, which follows the holding element to expand
10 the pressure chamber to damp vibration of a meniscus of the ink in the nozzle
11 orifice; and
12 wherein the waveform controller defines the duration of the holding
13 element.

1 20. The recording apparatus as set forth in claim 17, wherein the drive
2 signal is provided with a second drive pulse including:
3 a second expansion element, which expands the pressure chamber to
4 pull a meniscus of ink in the nozzle orifice toward the pressure chamber;
5 a second ejection element, which follows the second expansion
6 element to contract the pressure chamber to eject a center portion of the
7 meniscus as an ink droplet; and
8 a second damping element, which follows the second ejection element
9 to expand the pressure chamber to damp vibration of the meniscus; and
10 wherein the waveform controller defines the duration of the second
11 damping element.

1 21. The recording apparatus as set forth in claim 17, wherein the drive
2 signal is provided with a third drive pulse including:
3 an ejection pulse, which ejects an ink droplet from the nozzle orifice;
4 a damping pulse, which follows the ejection pulse to damp vibration of

5 a meniscus of ink in the nozzle orifice; and
6 a first connecting element, which connects a termination end of the
7 ejection pulse and an initial end of the damping pulse; and
8 wherein the waveform controller defines duration of the connecting
9 element.

1 22. The recording apparatus as set forth in claim 17, wherein the drive
2 signal is provided with a plurality of drive pulses for driving the pressure
3 generating element and a second connecting element which connects a
4 termination end of a preceding drive pulse and an initial end of a subsequent
5 drive pulse; and
6 wherein the waveform controller defines duration of the second
7 connecting element.

1 23. The recording apparatus as set forth in claim 17, wherein the drive
2 signal is provided with a characteristics changing element which changes
3 ejection characteristics of an ink droplet; and
4 wherein the waveform controller defines a control factor of the
5 characteristics changing element.

1 24. The recording apparatus as set forth in claim 23, wherein the drive
2 signal is provided with a fourth drive pulse including:
3 a first expansion element, which expands the pressure chamber such
4 an extent that an ink droplet is not ejected; and
5 a first ejection element, which follows the first expansion element to

6 contract the pressure chamber to eject an ink droplet from the nozzle orifice;
7 and

8 wherein duration of at least one of the first expansion element and the
9 first ejection element is defined by the waveform controller.

1 25. The recording apparatus as set forth in claim 23, wherein the drive
2 signal is provided with a fourth drive pulse including:

3 a first expansion element, which expands the pressure chamber such
4 an extent that an ink droplet is not ejected; and

5 a first ejection element, which follows the first expansion element to
6 contract the pressure chamber to eject an ink droplet from the nozzle orifice;
7 and

8 wherein a potential difference between an initial end and a termination
9 end of at least one of the first expansion element and the first ejection element
10 is defined by the waveform controller.

1 26. The recording apparatus as set forth in claim 23; wherein the drive
2 signal is provided with a fifth drive pulse including:

3 a first expansion element, which expands the pressure chamber such
4 an extent that an ink droplet is not ejected;

5 a first holding element, which follows the first expansion element to
6 hold the expanded state of the pressure chamber; and

7 a first ejection element, which follows the first expansion element to
8 contract the pressure chamber to eject an ink droplet from the nozzle orifice;
9 and

10 wherein the waveform controller defines duration of the first holding
11 element.

1 27. The recording apparatus as set forth in claim 23, wherein the drive
2 signal is provided with a sixth pulse including:

3 a second expansion element, which expands the pressure chamber to
4 pull a meniscus of ink in the nozzle orifice toward the pressure chamber; and

5 a second ejection element, which follows the second expansion
6 element to contract the pressure chamber to eject a center portion of the
7 meniscus as an ink droplet; and

8 wherein duration of at least one of the second expansion element and
9 the second ejection element is defined by the waveform controller.

1 28. The recording apparatus as set forth in claim 23, wherein the drive
2 signal is provided with a sixth pulse including:

3 a second expansion element, which expands the pressure chamber to
4 pull a meniscus of ink in the nozzle orifice toward the pressure chamber; and

5 a second ejection element, which follows the second expansion
6 element to contract the pressure chamber to eject a center portion of the
7 meniscus as an ink droplet; and

8 wherein a potential difference between an initial end and a termination
9 end of at least one of the second expansion element and the second ejection
10 element is defined by the waveform controller.

1 29. The recording apparatus as set forth in claim 23, wherein the drive
2 signal is provided with a seventh pulse including:

3 a second expansion element, which expands the pressure chamber to
4 pull a meniscus of ink in the nozzle orifice toward the pressure chamber;

5 a second holding element, which follows the second expansion
6 element to hold the expanded state of the pressure chamber; and

7 a second ejection element, which follows the second holding element
8 to contract the pressure chamber to eject a center portion of the meniscus as
9 an ink droplet; and

10 wherein the waveform controller defines duration of the second holding
11 element.

1 30. The driving method as set forth in claim 14, wherein the plurality of
2 ranks includes at least a first rank which indicates the measured natural period
3 is as per a designed criterion, a second rank which indicates the measured
4 natural period is shorter than the designed criterion, and a third rank which
5 indicates the measured natural period is longer than the designed criterion.

1 31. The recording apparatus as set forth in claim 17, further comprising: a
2 memory, which electrically stores information indicating the classified rank, the
3 memory electrically connected to the waveform controller.

1 32. The recording apparatus as set forth in claim 17, further comprising:
2 a rank indicator, provided with the recording head to indicate the
3 classified rank thereof so as to be optically readable; and

4 an optical reader, which optically reads the classified rank indicated by
5 the rank indicator,

6 wherein the waveform controller acquires the classified rank read by
7 the optical reader.

1 33. The recording apparatus as set forth in claim 17, wherein the pressure
2 generating element is a piezoelectric vibrator.

1 34. The recording apparatus as set forth in claim 17, wherein the pressure
2 generating element is a heating element.

1 35. A ink jet recording head, manufactured by the method as set forth in
2 any one of claims 1 to 13.

1 36. The recording head as set forth in claim 35, wherein the pressure
2 generating element is a piezoelectric vibrator.

1 37. The recording apparatus as set forth in claim 35, wherein the pressure
2 generating element is a heating element.